UNIVERSITI PUTRA MALAYSIA

RADIATION-INDUCED SYNTHESIS AND CHARACTERIZATION OF COPPER AND CHROMIUM NANOPARTICLES

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RADIATION-INDUCED SYNTHESIS AND CHARACTERIZATION OF COPPER AND CHROMIUM NANOPARTICLES

By

NAJAH SYAHIRAH BINTI MOHD NOR

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

December 2011

DEDICATION

TO MY FAMILY

MOHD NOR HJ MANSOR

LATIFAH HJ ABU SAMAH

NORZALIFAH AIDA

MOHD HISYAMMUDDIN

HAMI BAZILAH

MOHD DANIAL

MUHAMMAD ASYRAF

Thank you for the inspiration and encouragement in everything I do.

Abstract of the thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of requirement for the degree Master of Science

RADIATION-INDUCED SYNTHESIS AND CHARACTERIZATION OF COPPER AND CHROMIUM NANOPARTICLES EMBEDDED IN POLYMER MATRIX

By

NAJAH SYAHIRAH BINTI MOHD NOR

December 2011

Chairman: Professor Elias Saion, PhD

Faculty: Science

Many of researchers nowadays synthesize Cu and Cr nanoparticles using chemical and electrochemical method which contribute to the complicated synthesizing process and reduction of metal ions cannot be carried out without using reducing agent. Gamma irradiation method was successfully applied to the preparation of Cu and Cr nanoparticles embedded in PVA and PVP polymer matrix in aqueous solution under ambient temperature. The aqueous solution of $CuCl_2$ and $CrCl_3$ blend in both polymer matrixes were irradiated with ^{60}Co gamma rays to doses up to 50 kGy. The aqueous solution of metal/polymer creating hydrated electron, primary radicals and molecules upon the γ irradiation process. The optical properties were employed by using UV-Visible spectrophotometer to examine the optical properties of Cu and Cr nanoparticles. The absorption peaks for Cu and Cr nanoparticles dispersed in PVA and PVP have been observed increase with increase of γ-irradiation doses and demonstrates slightly blue shift due to the smaller particles size with increase of dose.

The absorption spectra of Cu and Cr nanoparticles were analyzed further for absorption edge and energy of conduction band. From the plot of absorption coefficient α versus photon energy $h\nu$, the absorption edge of both nanoparticles was found increases when the dose increases for Cu and Cr nanoparticles dispersed in both PVA and PVP polymer matrix. The energy of conduction band of Cu and Cr nanoparticles was determined by the photon energy equation, $E_{cb} = hc/\lambda_{max}$ where h is Planck's constant, c is the speed of light and λ_{max} is the wavelength value of maximum intensity of surface plasmon peaks. The value of energy conduction band calculated from the photon energy equation was found to be increases as dose increase up to 50 kGy for both Cu and Cr nanoparticles dispersed in PVA and PVP polymer matrix.

The crystalline structure of Cu and Cr nanoparticles dispersed in PVA and PVP polymer matrix was investigate through X-ray diffraction analysis. Pure metallic Cu with face-centered cubic structure was observed for all irradiated samples dispersed in both PVA and PVP polymer matrix. Cr nanoparticles dispersed in PVA and PVP was observed with body centered cubic structure. The intensity of both Cu and Cr nanoparticles dispersed in PVA and PVP increased with increase of γ-irradiation dose.

The size of Cu and Cr nanoparticles was determined by TEM analysis. The size of the nanoparticles was observed to be decrease with increase of gamma radiation doses. The average size of Cu and Cr nanoparticles dispersed in PVA is smaller than dispersed in PVP because of the polymer chain of PVA is longer than PVP. The agglomeration process of Cu and Cr nanoparticles occurred more in PVP polymer matrix due to the shorter polymer chain.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

RADIASI MENDORONG SINTESIS DAN PENCIRIAN NANOPARTIKEL KUPRUM DAN KROMIUM TERTANAM DALAM MATRIKS POLIMER

Oleh

NAJAH SYAHIRAH BINTI MOHD NOR

Disember 2011

Pengerusi: Profesor Elias Saion, PhD

Fakulti: Sains

Kaedah penyinaran gamma telah berjaya diaplikasikan untuk penyediaan Cu dan Cr nanopartikel yang tertanam pada matriks polimer PVA dan PVP dalam larutan akueus di bawah suhu ambien. Larutan campuran $CuCl_2$ dan $CrCl_3$ di dalam kedua-dua matriks polimer diradiasikan dengan ^{60}Co sinar gamma sehingga 50 kGy. Larutan akueus logam/polimer mewujudkan elektron terhidrat, radikal utama, dan molekul apabila proses penyinaran gamma. Ciri-ciri optik diukur dengan menggunakan meterspektrum UV-sinar tampak untuk memeriksa ciri-ciri optik bagi Cu dan Cr nanopartikel. Puncak-puncak penyerapan bagi Cu dan Cr nanopartikel tertanam di dalam PVA dan PVP telah diperhatikan meningkat dengan peningkatan dos sinaran gamma dan menunjukkan peralihan biru disebabkan penurunan saiz nanopartikel dengan peningkatan dos. Spektra penyerapan Cu dan Cr nanopartikel dianalisis dengan lebih lanjut untuk penyerapan pinggir dan tenaga jalur konduksi. Daripada plot pekali penyerapan α lawan tenaga foton $h\nu$, penyerapan pinggir untuk kedua-dua

nanopartikel tertanam di dalam PVA dan PVP didapati meningkat dengan peningkatan dos sinaran gamma. Tenaga jalur konduksi bagi Cu dan Cr nanopartikel ditentukan dari persamaan tenaga foton, $E_{cb} = hc/\lambda_{max}$ di mana h ialah pemalar Planck, c ialah halaju cahaya dan λ_{max} ialah panjang gelombang bagi intensiti maksimum permukaan puncak Plasmon. Nilai tenaga jalur konduksi yang dikira daripada persamaan tenaga foton didapati meningkat dengan peningkatan dos sinaran gamma sehingga 50 kGy untuk kedua-dua Cu dan Cr nanopartikel yang tertanam di dalam PVA dan PVP.

Struktur kristal Cu dan Cr nanopartikel yang tersebar di dalam PVA dan PVP polimer matriks disiasat menerusi analisis pembelauan sinar-X. Logam tulen Cu dengan struktur kubus berpusat muka diperhatikan untuk semua sampel diradiasi yang tersebar dalam PVA dan PVP polimer matriks. Cr nanopartikel tertanam di dalam PVA dan PVP di dapati berstruktur kubus berpusat tengah. Keamatan untuk kedua-dua Cu dan Cr nanopartikel tertanam di dalam PVA dan PVP meningkat dengan peningkatan dos sinaran gamma.

Saiz Cu dan Cr nanopartikel diukur menggunakan analisis mikroskopi transmisi electron (TEM). Saiz kedua-dua nanopartikel berkurangan dengan peningkatan dos radiasi gamma. Saiz purata Cu dan Cr nanopartikel tertanam di dalam PVA adalah lebih kecil berbanding yang tertanam di dalam PVP disebabkan oleh rantaian polimer PVA yang lebih panjang berbanding PVP. Proses aglomerasi Cu dan Cr nanopartikel banyak berlaku di dalam PVP polimer matriks kerana rantaian polimer yang lebih pendek.

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I certify that a Thesis Examination Committee has met on 05/12/2011 to conduct the final examination of Najah Syahirah binti Mohd Nor on her thesis entitled "Radiation Induced Synthesis and Characterization of Copper and Chromium Nanoparticles Embedded in Polymer Matrix" in accordance with the Universities and University College Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U. (A) 106] 15 March 1998. The committee recommends that the student be awarded the Master of Science.

Members of the Thesis Examination Committee were as follows:

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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Date:

DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

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NAJAH SYAHIRAH BINTI MOHD NOR

Date: 5 December 2011

TABLE OF CONTENTS